

Launch Vehicle Design Process Characterization Enables Design/Project Tool

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***Presented at
The Huntsville Simulation Conference
HSC 2001
Huntsville, Alabama, October 3 and 4, 2001***

***Presented by
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Purpose

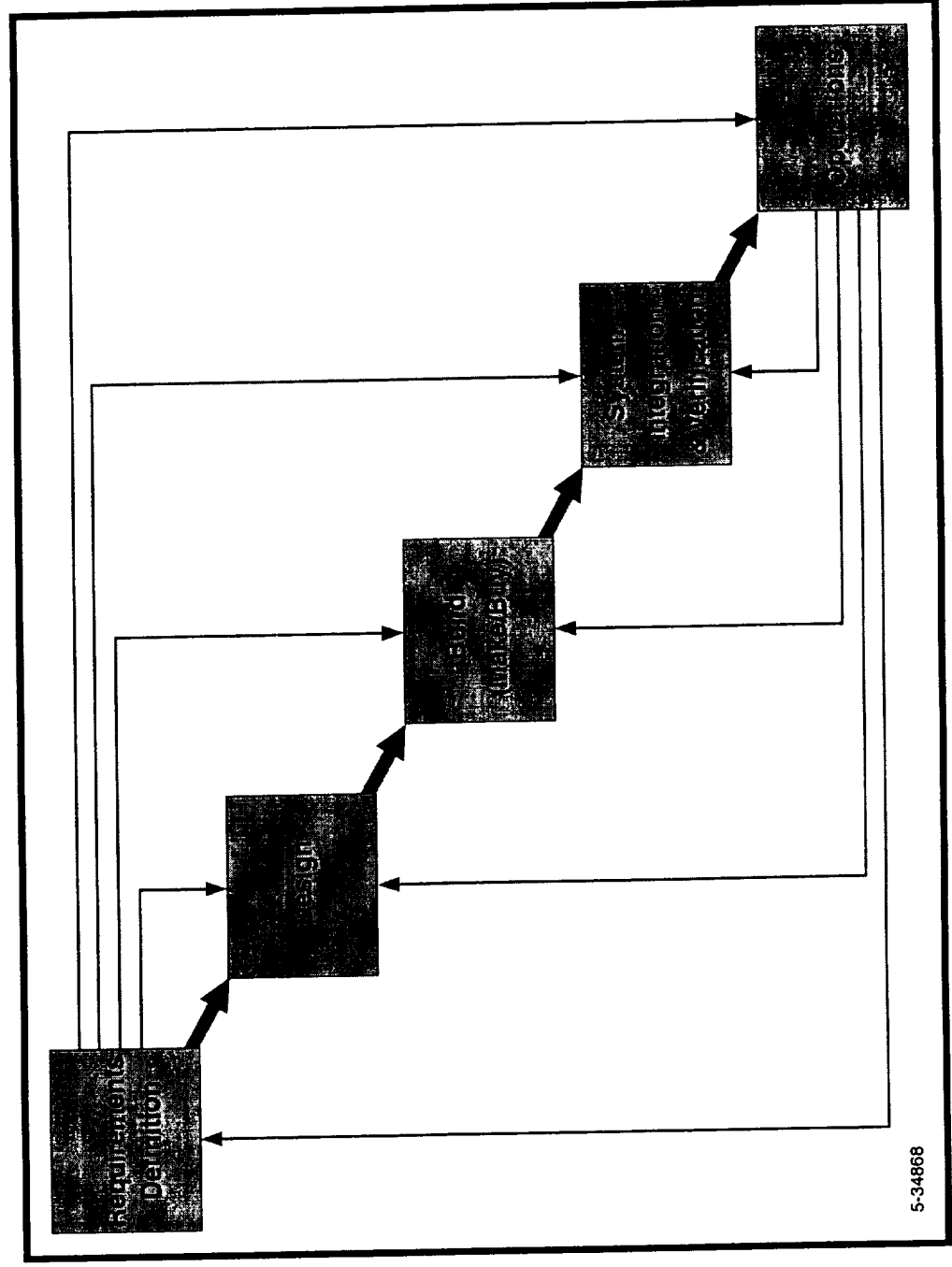
- **Provide an overview characterization of the launch vehicle design process**
- **Delineate design/project tool to identify, document and track pertinent data**

Launch Vehicle Design Process

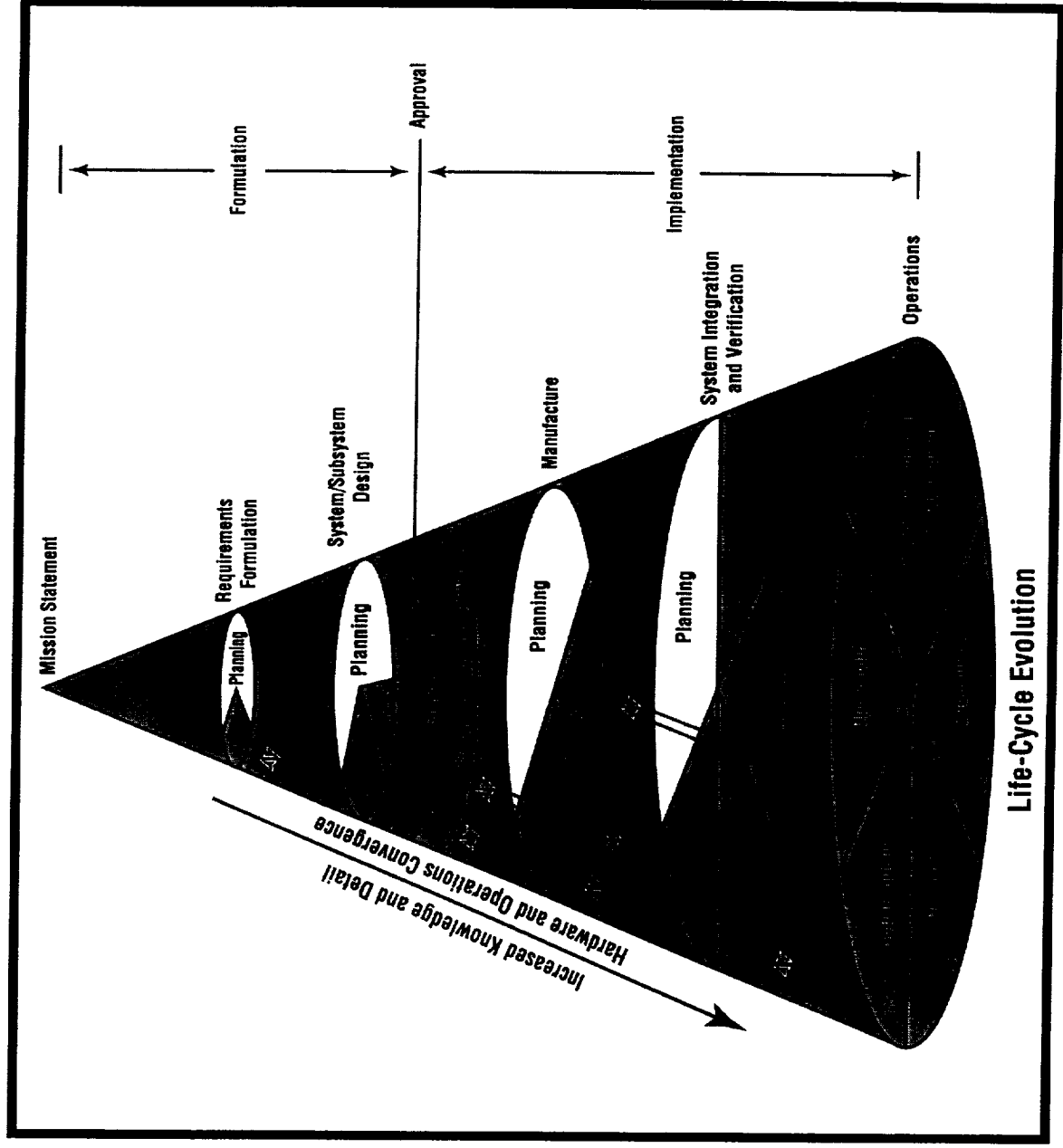
Features

- **Vehicle Life Cycle**
- **Fundamental premises**
 - **Industrial specialization**
 - **T-model**
- **Compartmentalization**
 - **Hardware subsystems**
 - **Design functions**
 - **Discipline functions**
- **Technical integration**

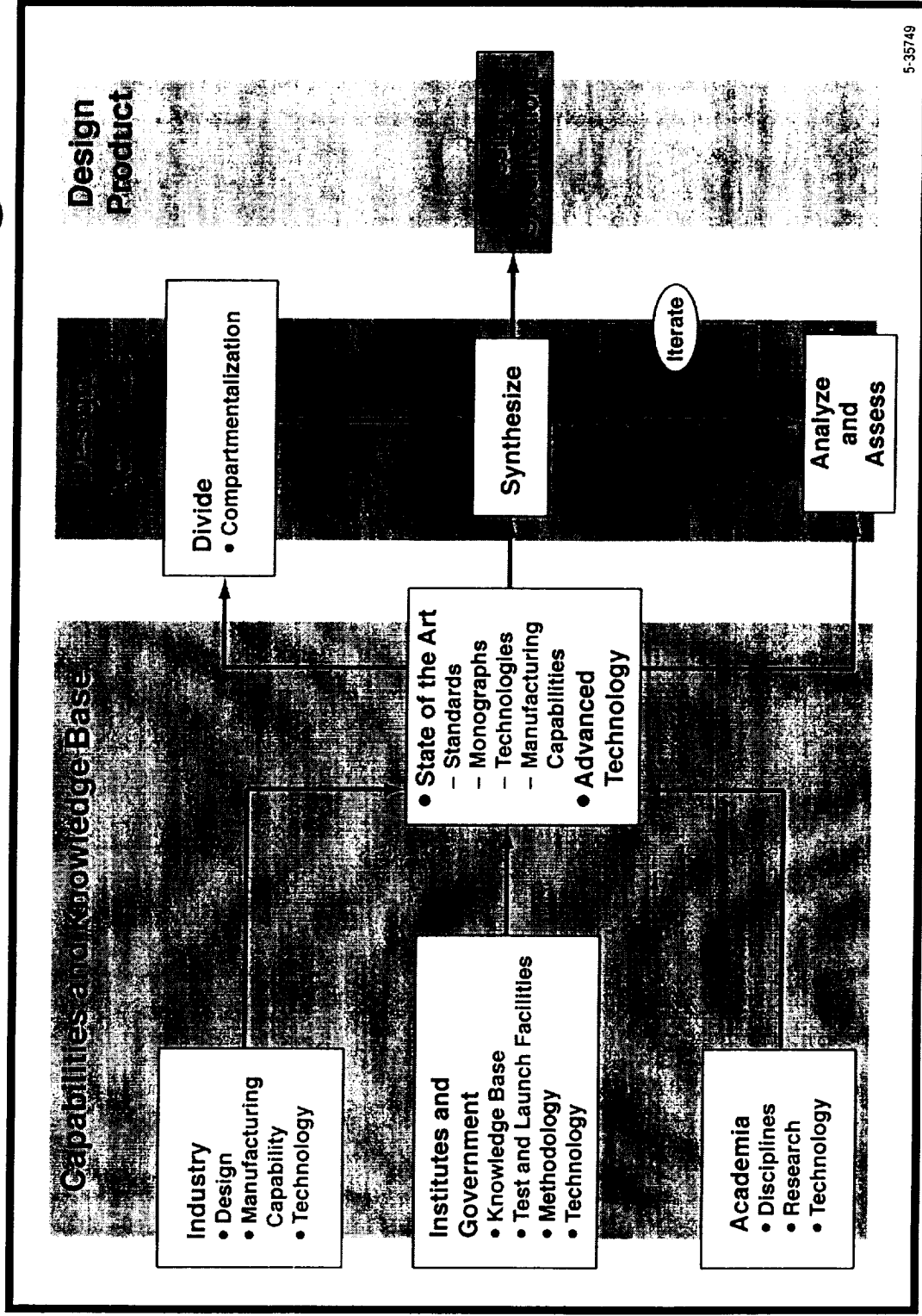
Vehicle Life-Cycle Flow Chart



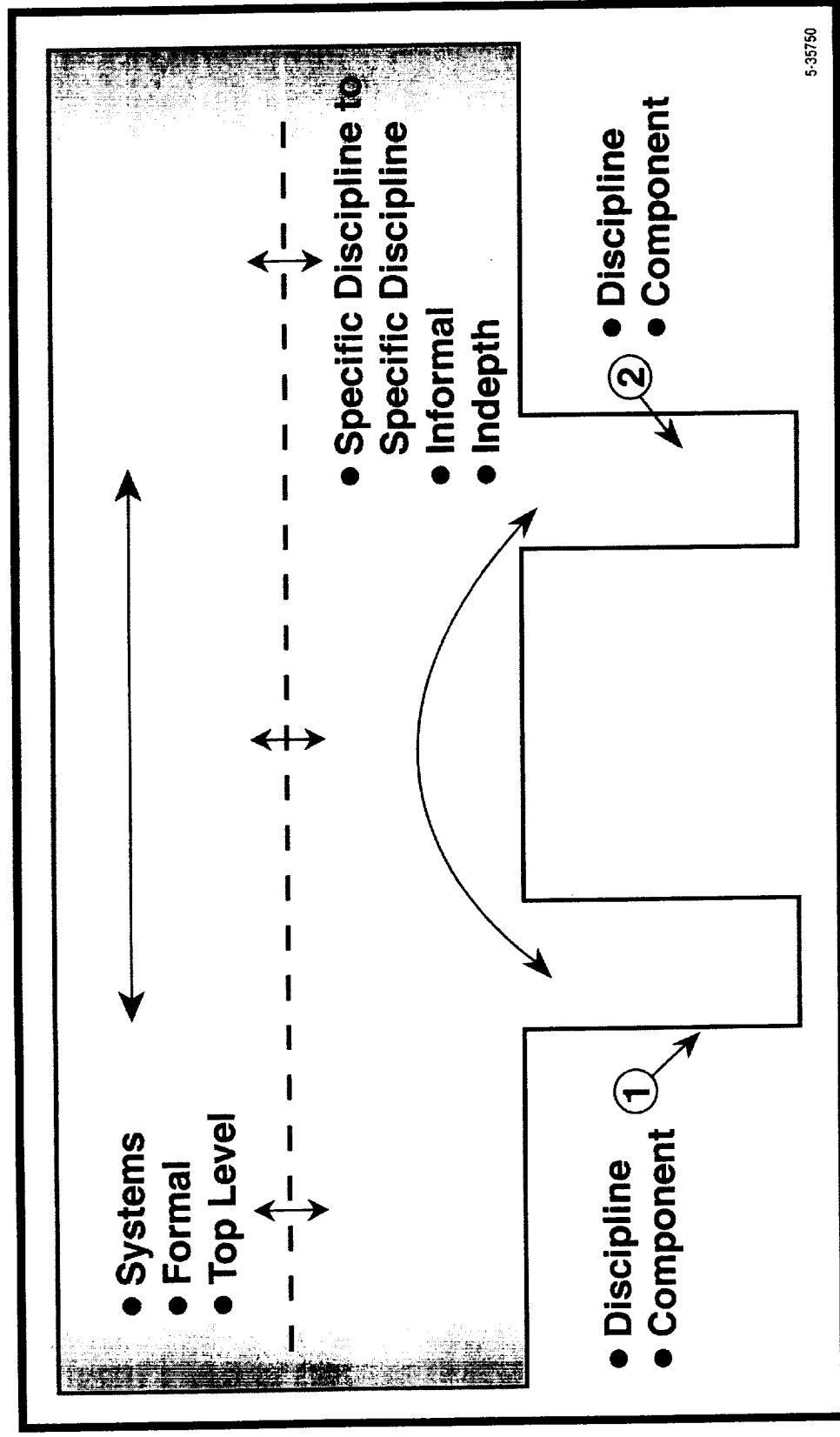
Design Process Life-Cycle Evolution



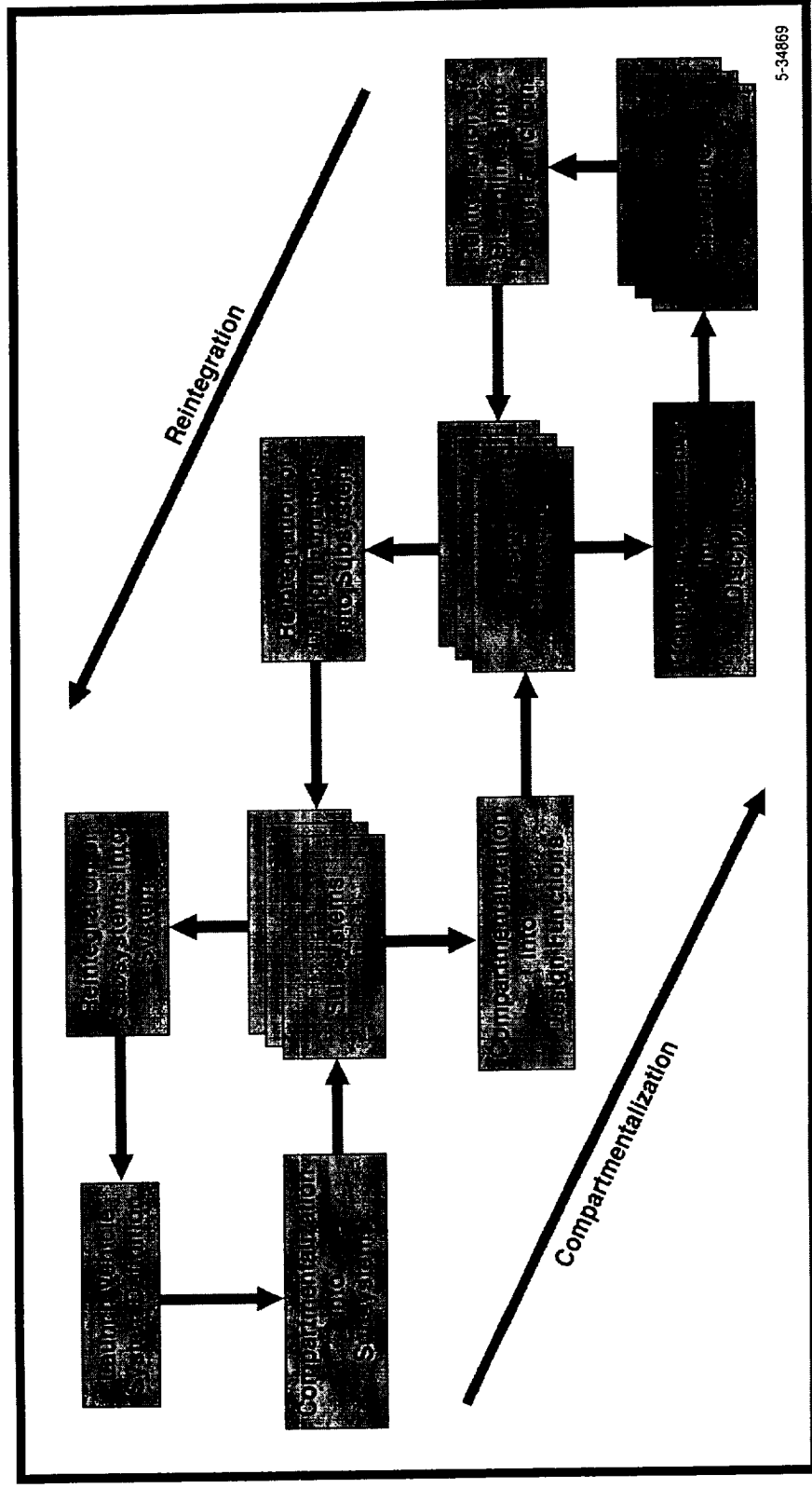
Influence of Aerospace Infrastructure and Specialization on Design



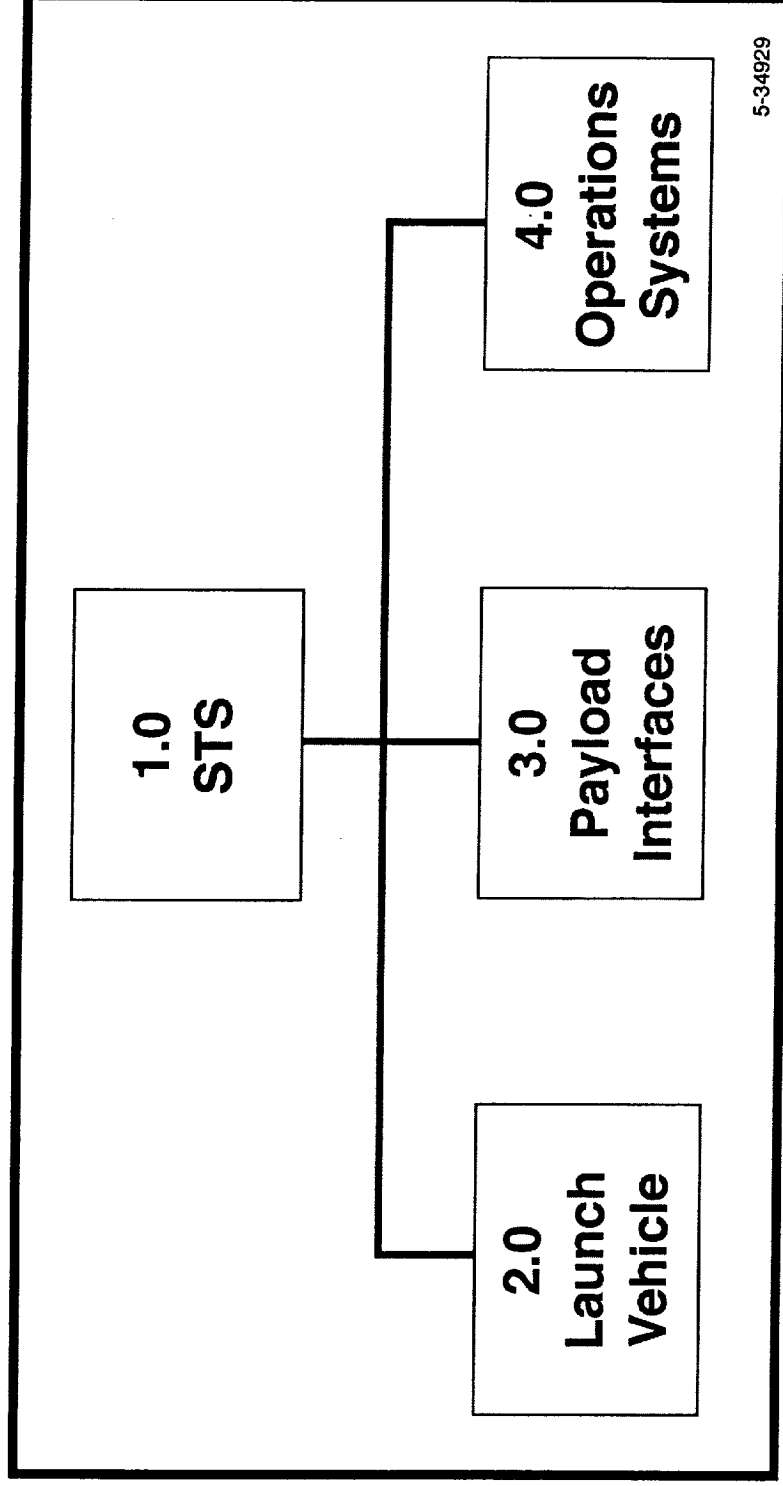
T-Model for Technical Integration



Compartmentalization and Reintegration

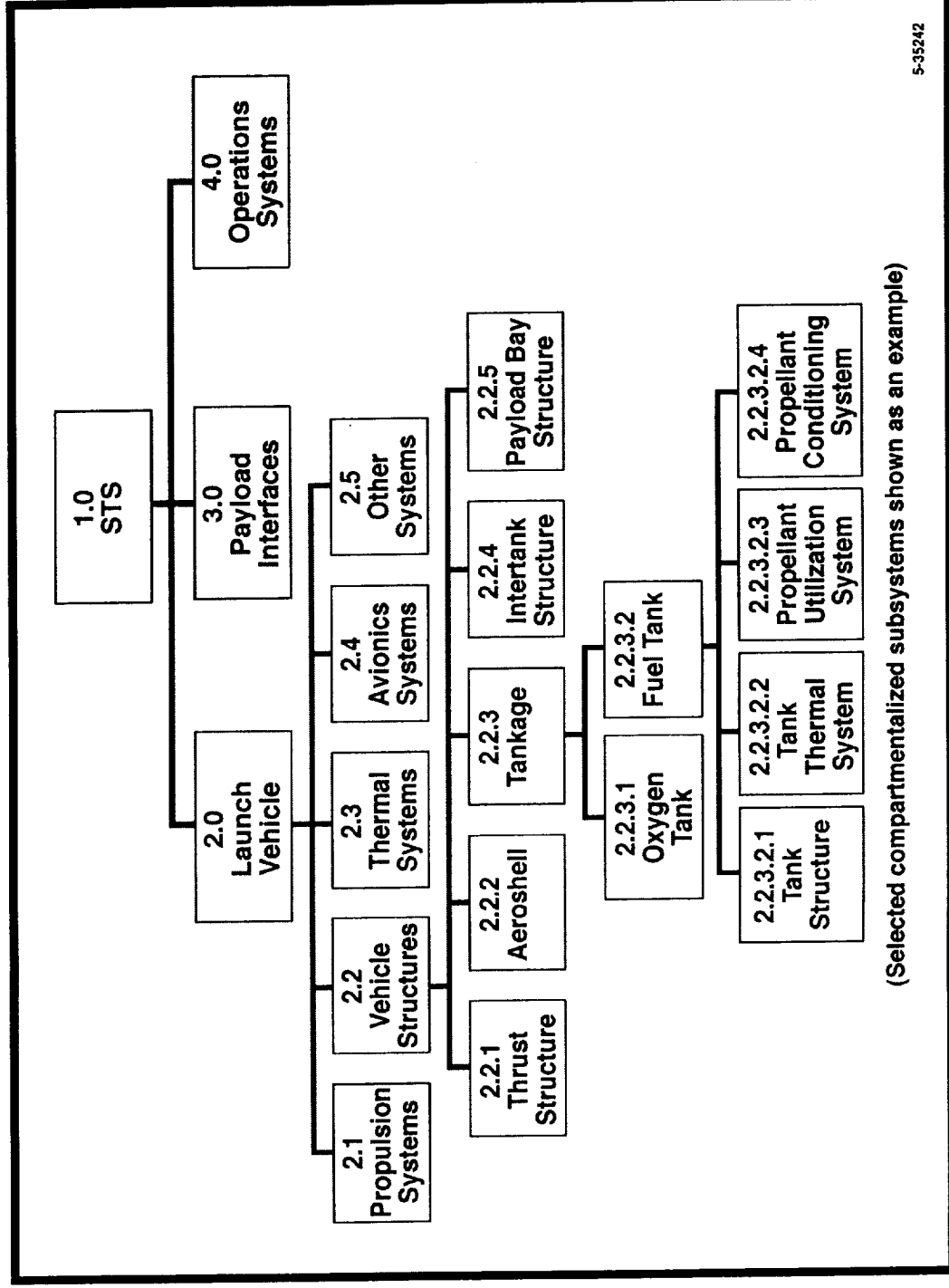


STS Compartmentalization



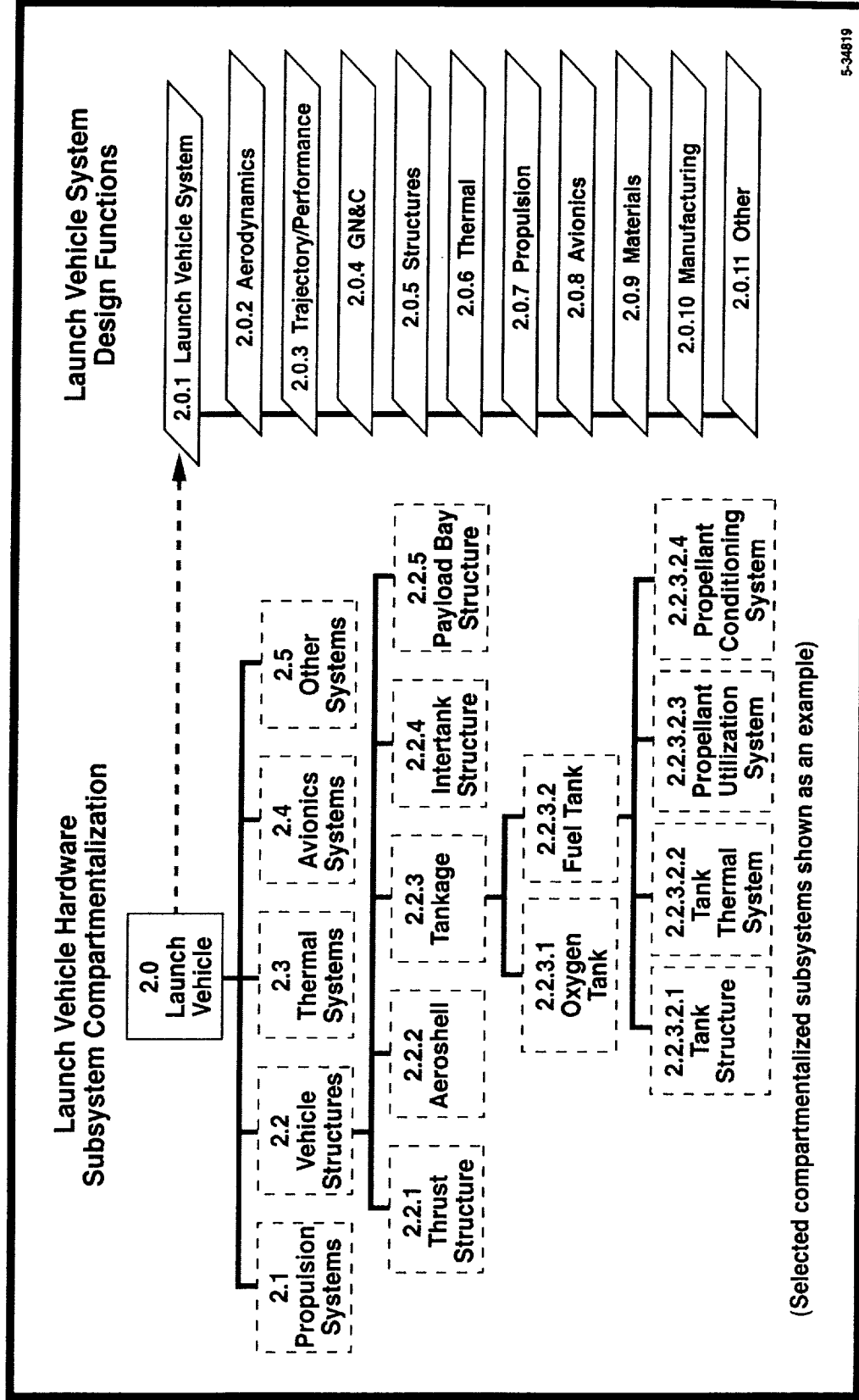
Compartmentalization

Launch Vehicle Hardware Subsystem Compartmentalization



Compartmentalization

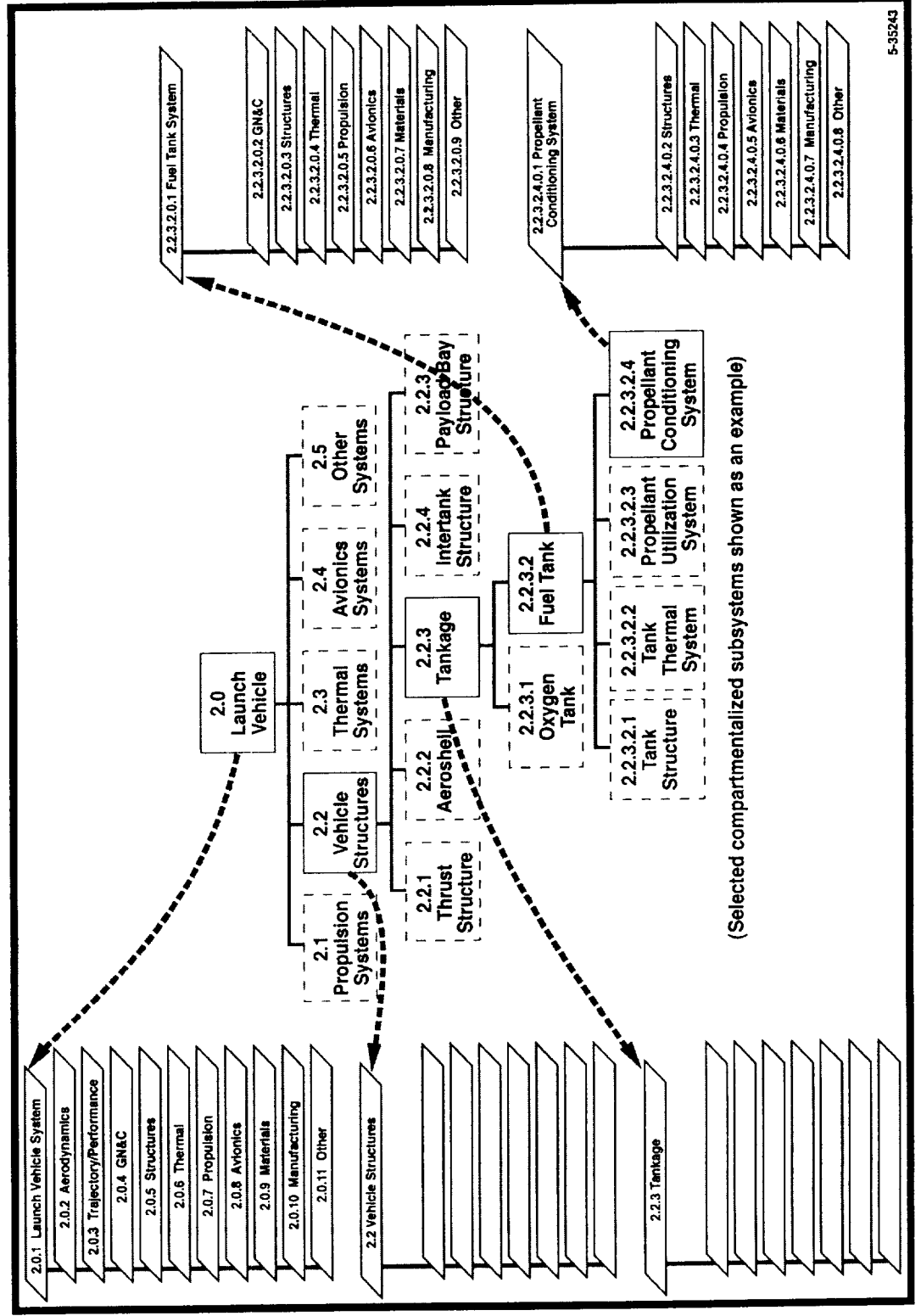
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Compartmentalization

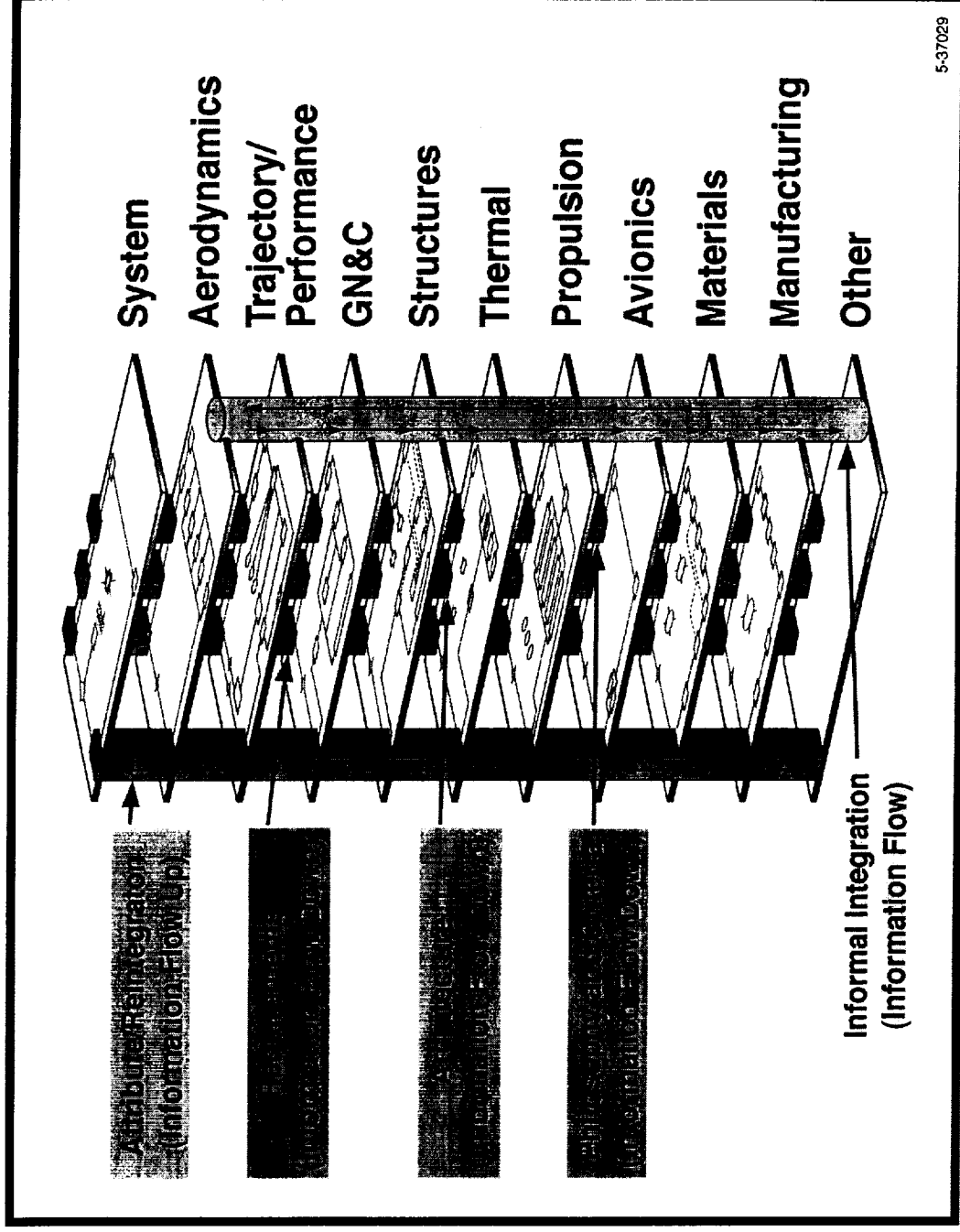
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Typical Design Functions

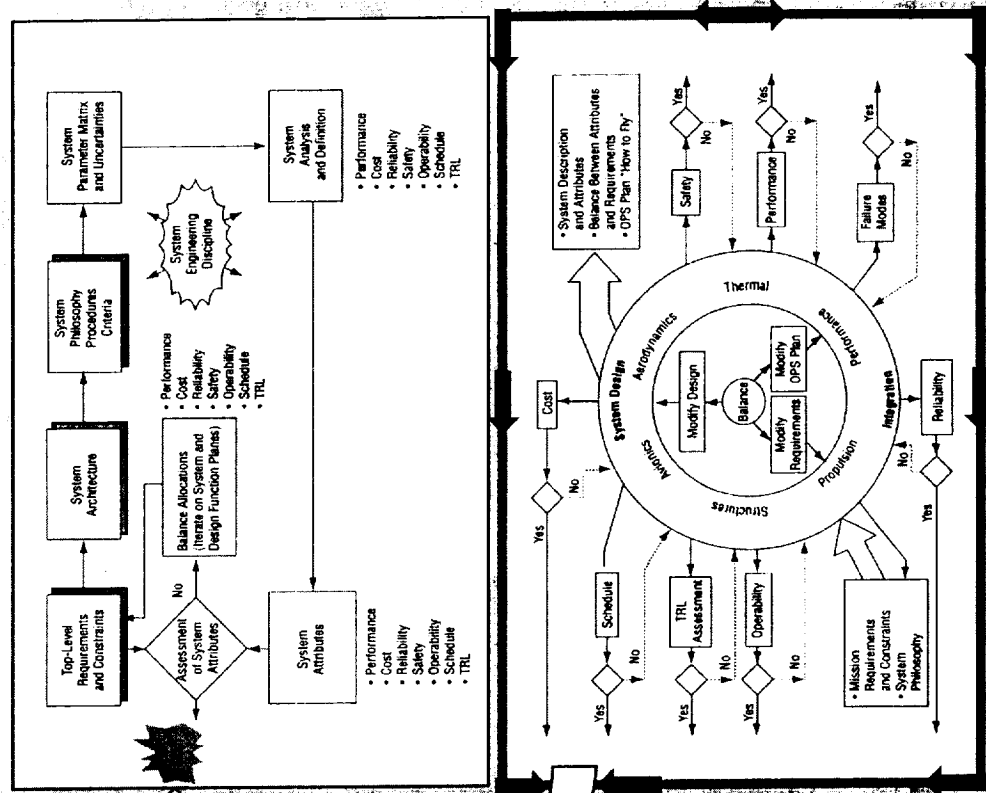
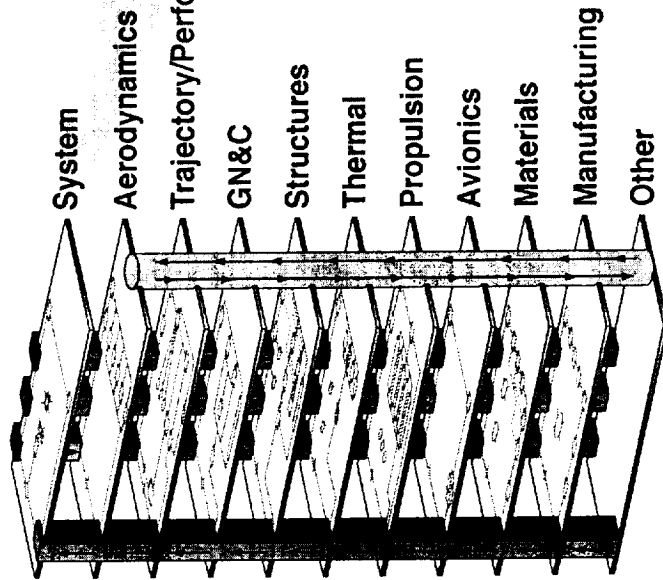


(Selected compartmentalized subsystems shown as an example)

Technical Integration of System, Design, and Discipline Functions

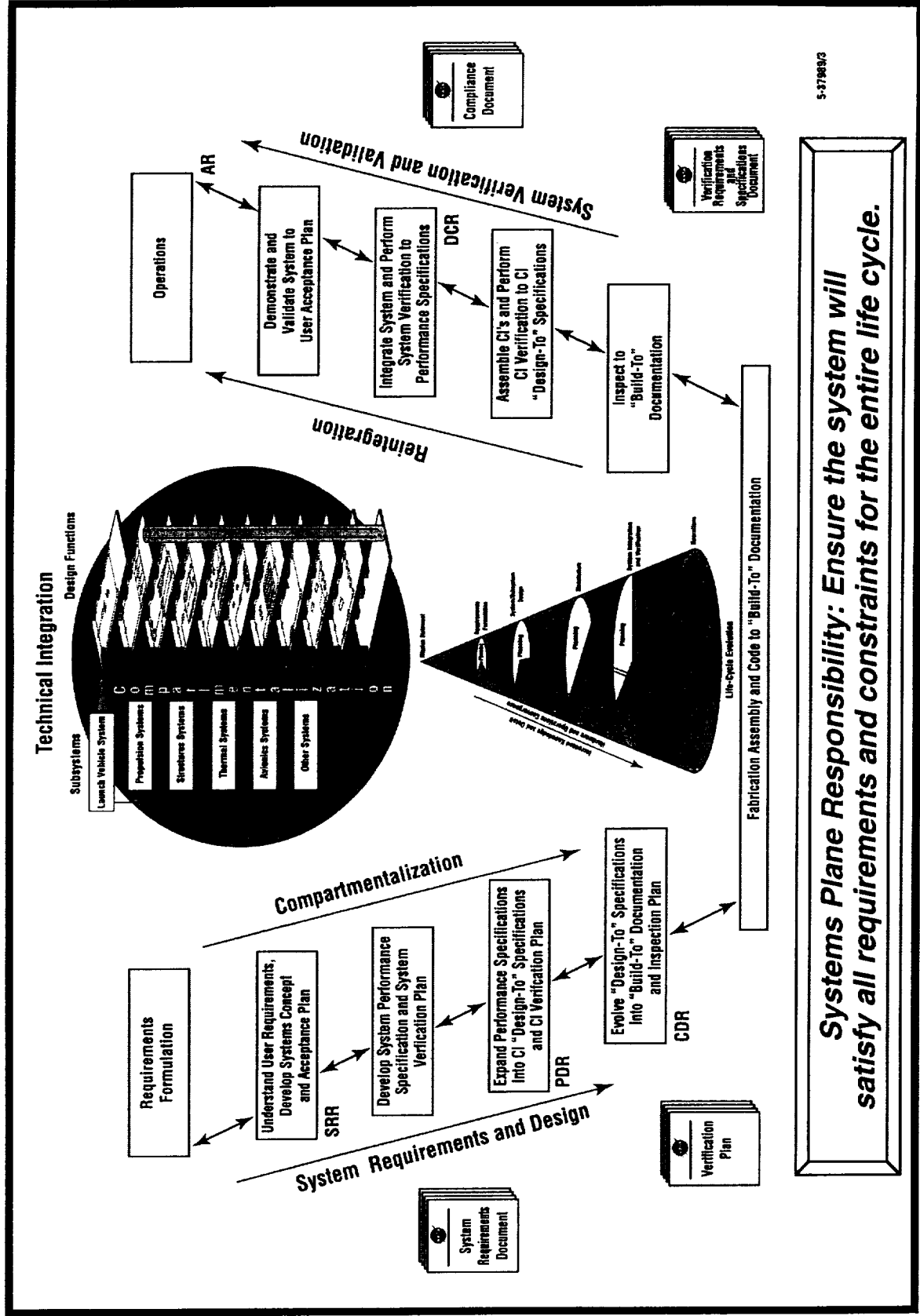


System Design Function



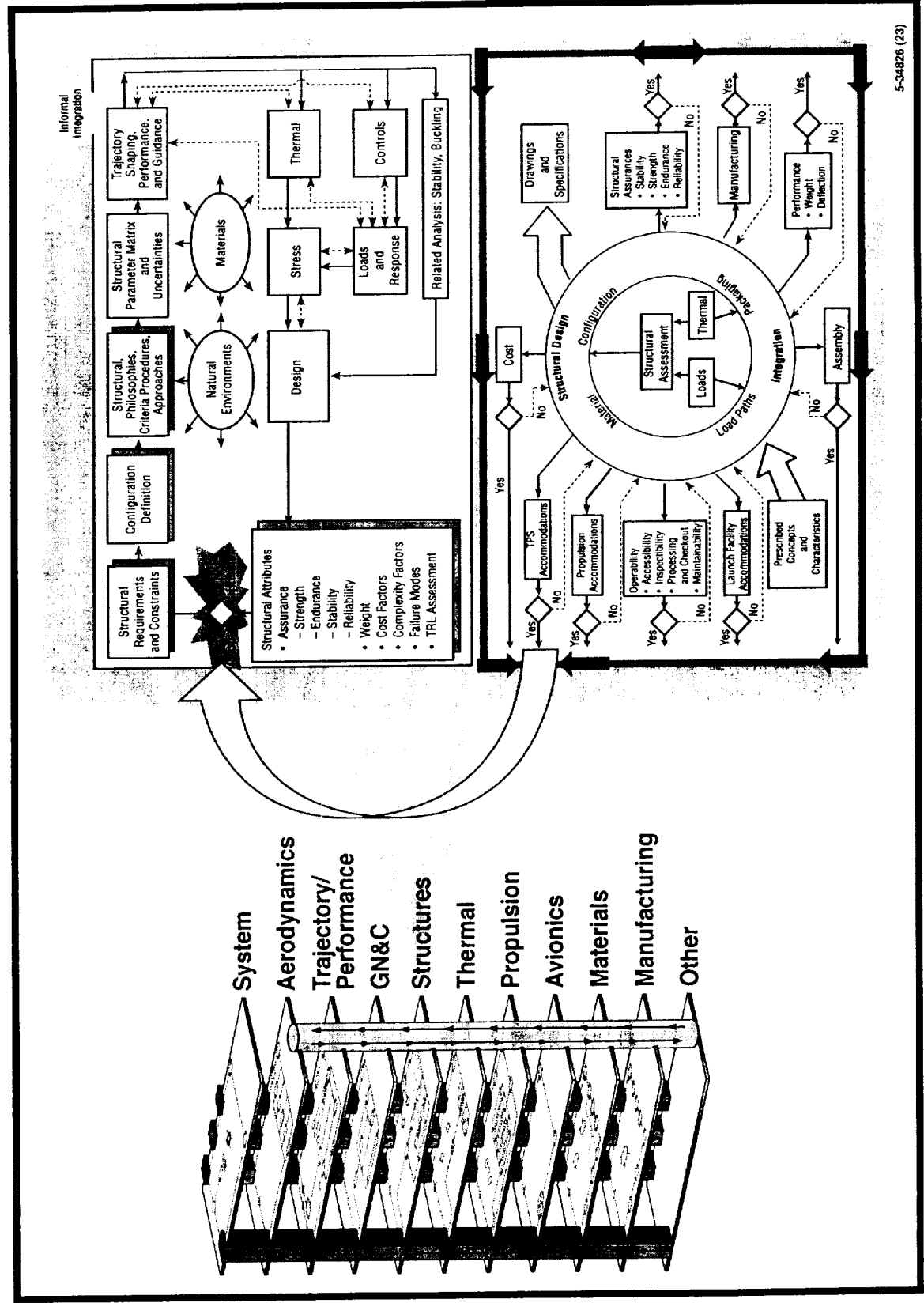
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Systems Plane Overview



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Structures Design Function



System Plane Responsibilities

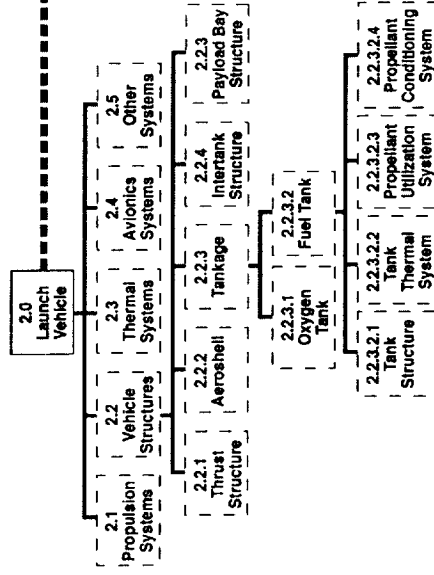
- Provide technical leadership
- Define and allocate requirements
- Define system philosophies
- Develop activities plan
- Synthesize architectural alternatives
- Compare and screen with historical database
- Compartmentalize and reintegrate subsystems/design function
- Define and manage interfaces and interactions
- Integrate design and discipline functions for balanced design (technical integration)
- Perform system trade studies to balance system attributes
- Develop plans for verification, manufacturing, and operations
- Track critical technologies and issues
- Track technical performance parameters/margins
- Perform risk assessment
- Provide configuration control
- Orchestrate reviews
- Document results.

Other Design Function Planes Responsibilities

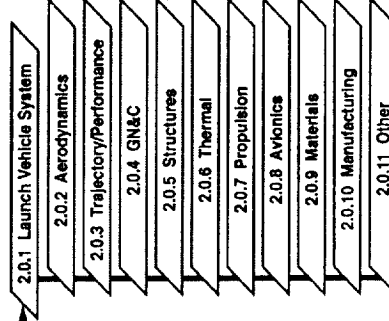
- Requirements
- Acquire and assess allocated requirements
- Develop natural and induced environments for all mission events
- Develop derived requirements
- Determine supporting discipline criteria
- Configure requirements for verification.
- Design
- Synthesize design alternatives
- Compare and screen with historical database
- Determine and evaluate critical technologies
- Perform design analysis and test (stability, transient, and quasistatic analysis for contributing disciplines)
- Determine attributes (performance, cost, reliability, operability, and safety)
- Trade and compare attributes
- Identify failure modes
- Perform uncertainty and sensitivity analysis
- Perform risk assessment
- Iterate, select, and mature design
- Develop drawings, specifications, and databases.
- Manufacturing
- Develop manufacturing plan
- Determine and certify critical processes
- Build.
- Verification
- Develop verification plan (test, analysis, similarity, etc.)
- Perform verification at appropriate levels
- Certify hardware/software.
- Operations
- Develop operations plan (assembly, checkout, launch, flight, return, refurbishment/maintenance)
- Determine operations database
- Establish operations constraints and procedures.

Categories of Compartmentalization

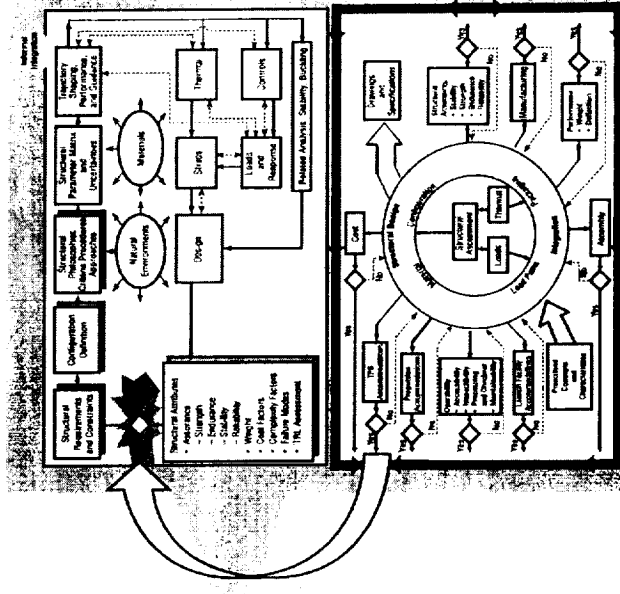
Hardware/Software Subsystems



Design Functions (Example Launch Vehicle System)

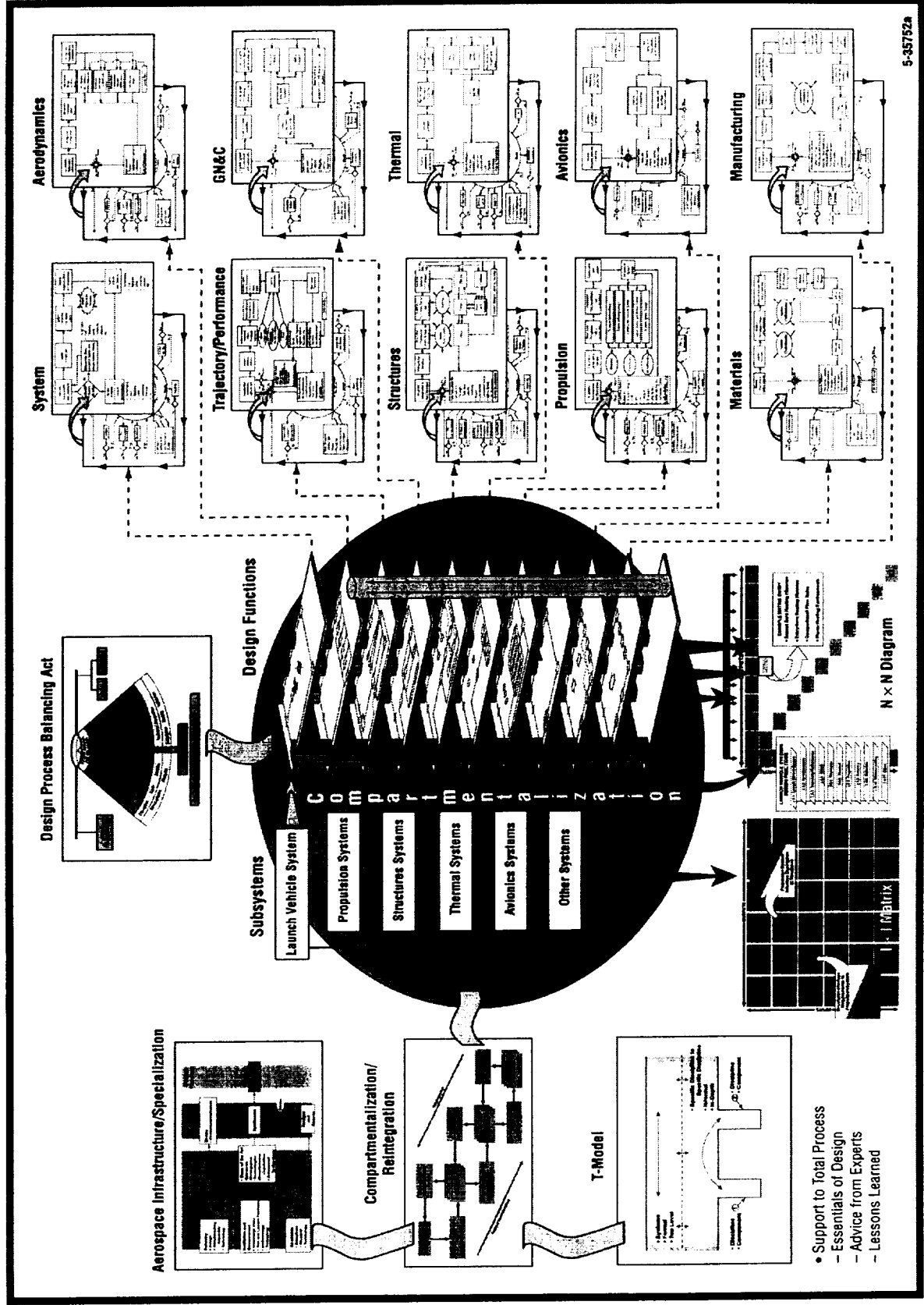


Discipline Functions (Example Disciplines Supporting Structures Design Function)



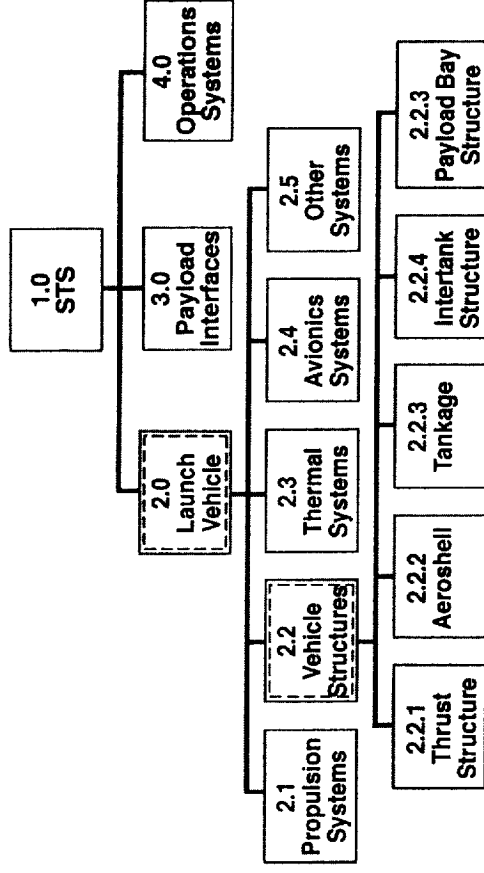
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Overview of Design Process



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I x I Matrices



STS	Launch Vehicle	Launch Vehicle	Payload Interfaces	Operations Systems
		Launch Vehicle		
			Payload Interfaces	
				Operations Systems

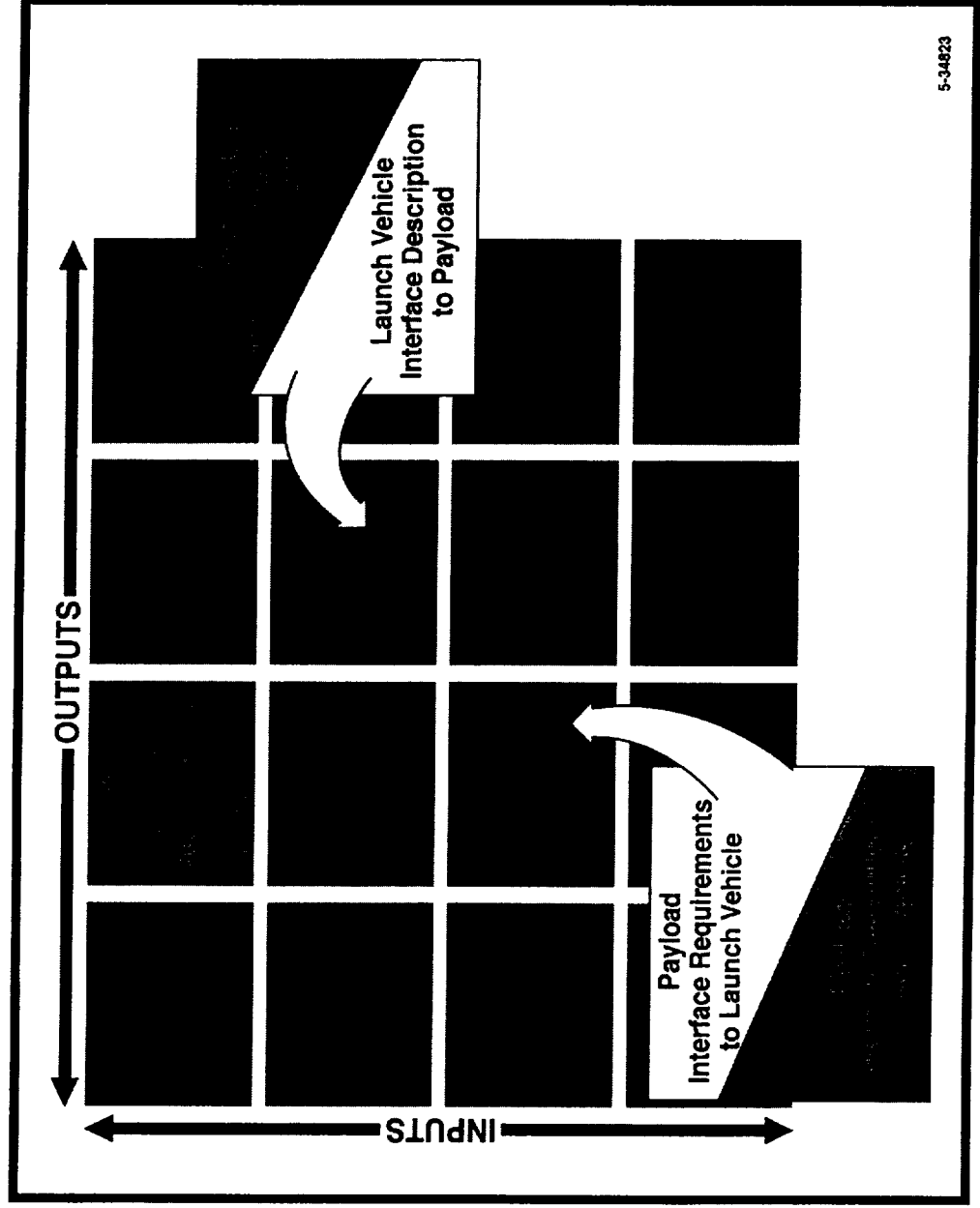
Launch Vehicle	Propulsion Systems	Vehicle Structures	Thermal Systems	Avionics Systems	Other Systems
	Propulsion Systems				
		Vehicle Structures			
			Thermal Systems		
				Avionics Systems	
					Other Systems

Vehicle Structures	Thrust Structures	Aeroshell	Tankage	Intertank Structures	Payload Bay Structures
	Thrust Structures				
		Aeroshell			
			Tankage		
				Intertank Structures	
					Payload Bay Structures

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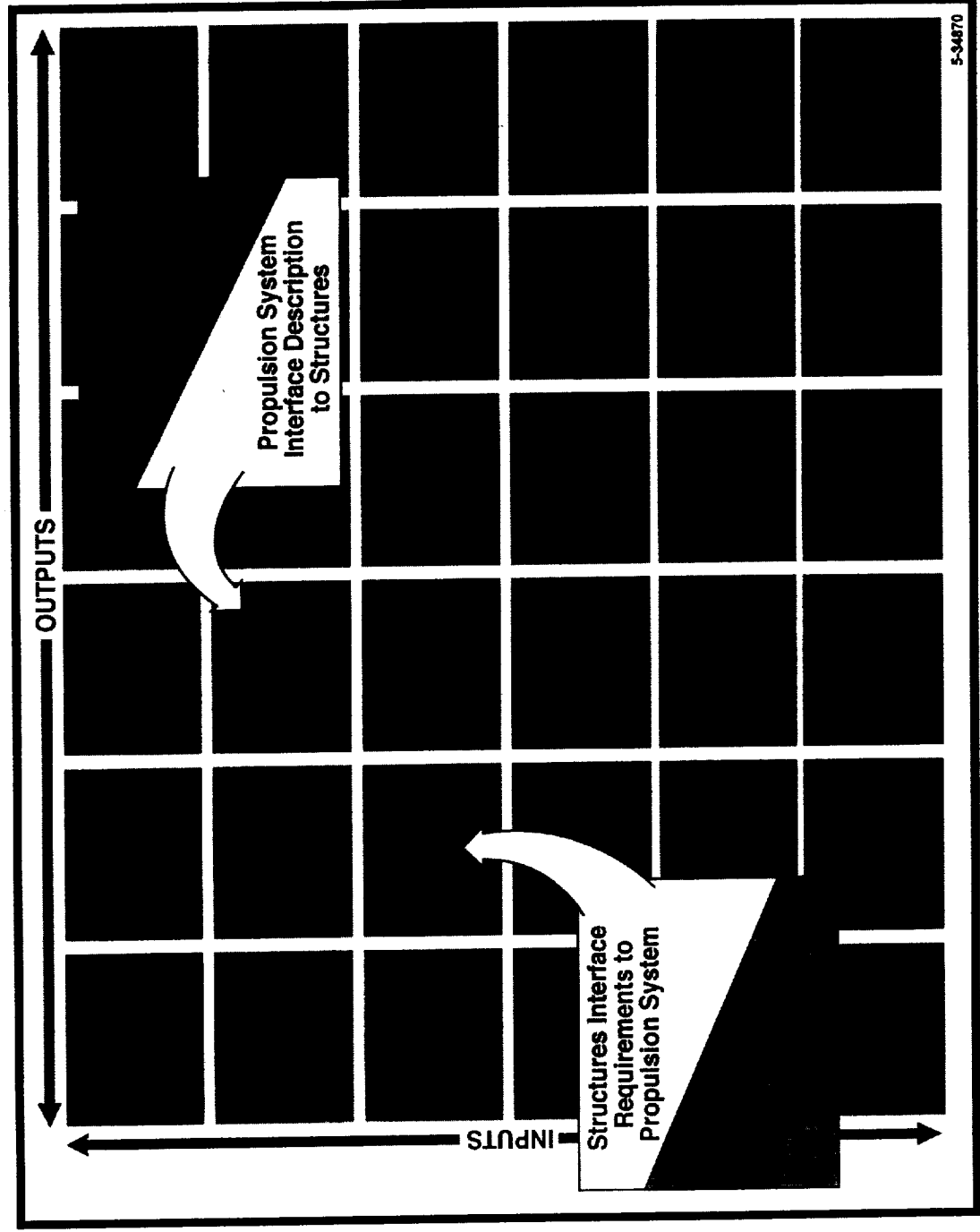
1 x 1 Matrix for STS

Interactions Among STS Subsystems

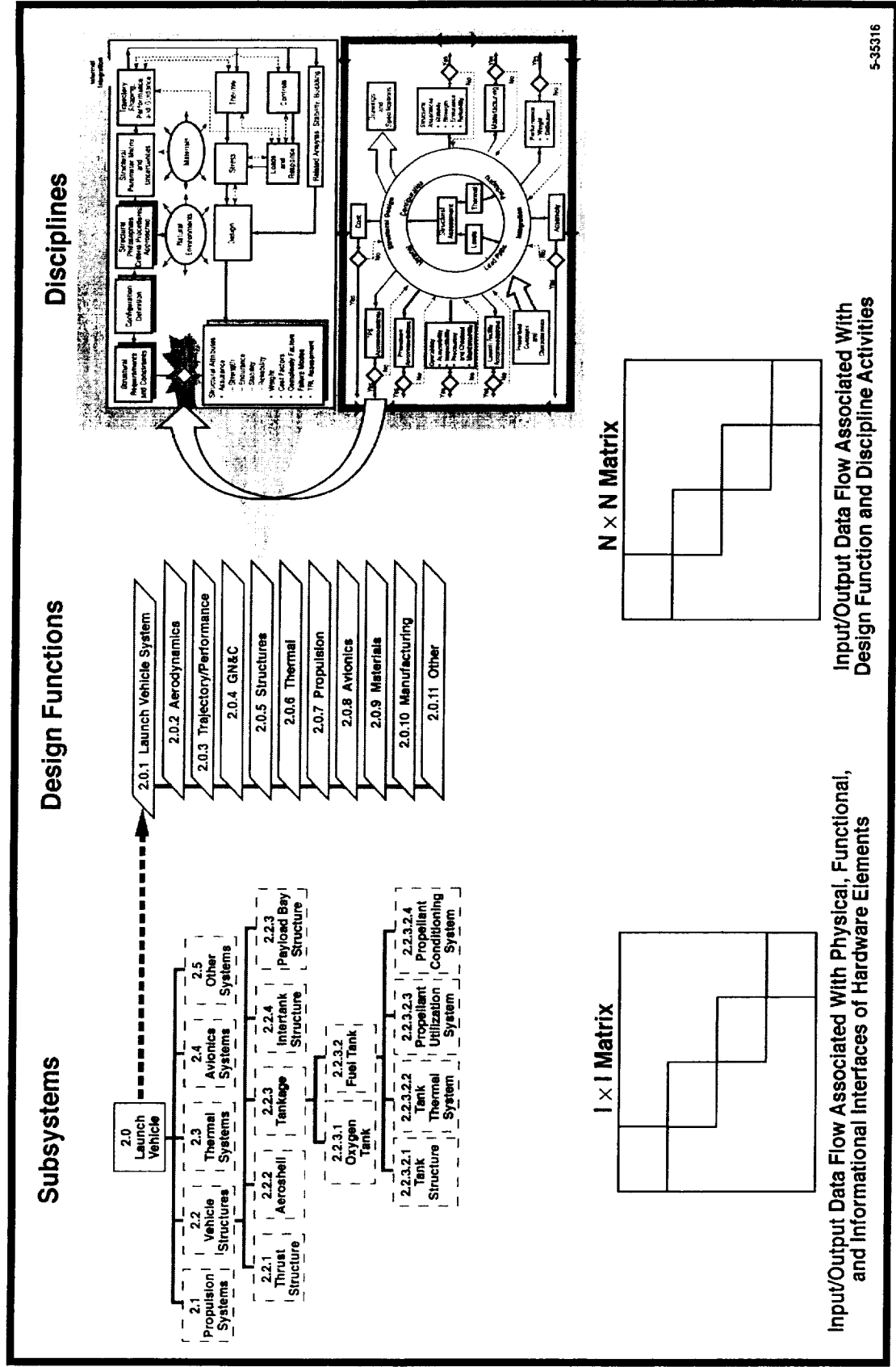


1 x 1 Matrix for Launch Vehicle

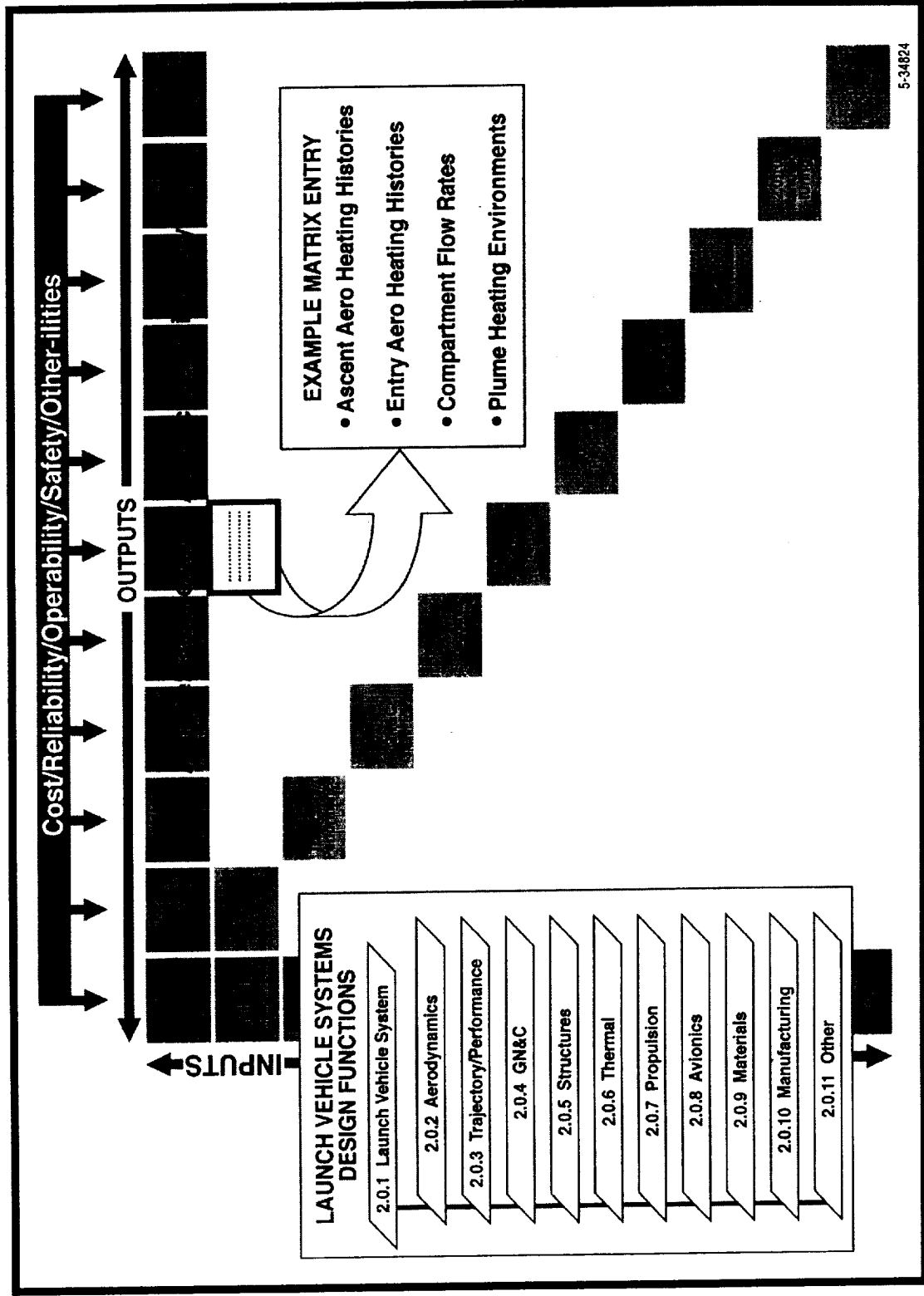
Interactions Among Launch Vehicle Subsystems



Matrices of Input/Output Data Flow



N x N Matrix for Launch Vehicle



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Integrated Information and Communication System (I²CS)

Need and Approach

- **Need: Improve the efficiency and fidelity of the launch vehicle design process through all stages**
- **Approach: Provide the means to—**
 - **1. Connect all process participants in the design process to archive valid/correct design information and ensure interactions are accounted**
 - **2. Implement advanced tools**

Typical Features

1. Residence and/or place holder for the design description and specifications, associated attributes, ICD's, and supporting data (this tool could be based upon the design process characterization model along with the N x N and I x I diagrams)
2. Real-time interactive communications system
3. Management related information system (this tool would include the WBS, cost-spending profiles, allocations, reserves, schedule, etc.)
4. Electronic mockup with fidelity consistent with the design stage
5. Flight performance simulation with fidelity consistent with the design stage that displays key performance indicators versus flight time
6. Advanced interactive MDO synthesis system that can search for architectures per given requirements and constraints but be driven by an optimization algorithm
7. Virtual reality design system that can focus on the vehicle system, element, subsystem, or part where the design participants can assess the realization of their design decisions in real time
8. Interactive synthesis tool with design-to models that include performance, cost, reliability, safety, operations, etc.

